

# technical brief

## A Need for Disinfection Alternatives

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Municipal Water and Wastewater Treatment Target*

For water suppliers, wastewater plant operators, food scientists, and a host of other industry decision-makers, chlorine has been the disinfectant of choice. Since the 1900s, chlorine has done an excellent job. Its use has resulted in the virtual elimination of many serious waterborne diseases, such as cholera, from the U.S., and immeasurably improving the food supply.

Recently, however, the use of chlorine has received more scrutiny, particularly in water treatment and food processing. Chlorine has proven less effective against some organisms and chemical disinfection has shown to lead to the formation of undesirable by-products. Further, a more environmentally-conscious public has let those who supply these products know that continued indiscriminate use of chlorine is unacceptable.

Part of the scrutiny and public concern is the result of the identification of new pathogens, such as *Cryptosporidium* and *Giardia* in water supplies. These organisms have proven more difficult to inactivate with conventional disinfectants. Further, for certain vulnerable segments of society, such as the young or immunosuppressed, these organisms have proven deadly.

In addition, chemical disinfectants like chlorine react with naturally occurring substances present in water to form disinfection by-products. In some cases, these by-products have been shown to be carcinogenic.

### **An Alternative: Electron Beam Irradiation**

These factors have led to the search for alternatives to conventional disinfectants.

Many newer alternatives rely on electricity, with one of the more provocative possibilities being electron beam irradiation. While e-beam disinfection has been proven effective for some time, the expense associated with generating electron beams has kept interest low. Thus, the poor economics of e-beam treatment has resulted in few applications of the technology in water or wastewater treatment.

According to EPRI research, by 1995 only one research facility (in Miami) used electron beam irradiation for disinfection with pilot scale flows. The facility disinfected a flow of 120 gallons per minute ( $0.45 \text{ m}^3/\text{m}$ ) using a dose between 500 and 850 krad. The costs for this treatment were approximately \$1.00 per 1000 gallons (\$0.26/ $\text{m}^3$ ). In addition, the technology presents serious engineering challenges in that the beam can penetrate only a short distance through the water. Thus, the Miami facility applied the e-beam to a 48-inch wide (1.2 m) falling-film of water. While effective, this method is inappropriate for larger flows typically encountered at water and wastewater treatment plants.

The focus of the Florida research was the use of e-beam to remove organic



Electron beam irradiation offers an alternative to chemical disinfection.

compounds from water. Such an application requires large dosages, so there is little data available on the effectiveness of electron beam irradiation of water with pathogens and microbes. What was available suggested that relatively low doses, even less than 100 krad, would suffice to disinfect potable water supplies. However, the emergence of newer pathogens has called this assumption into question.

## EPRI's SS&T Initiative

Given current problems with the technology and the need for better alternatives, EPRI's Municipal Water and Wastewater Program launched a Strategic Science & Technology project to assess the use of electron beams on the disinfection of water and wastewater. The project, which was begun in 1997, is beginning to yield some results. This *Technical Brief* summarizes the results obtained in 1999.

The focus of this research has been to identify possible radiosensitizers, which are compounds that will enhance the disinfectant effect of e-beam irradiation. The ideal radiosensitizer, besides lowering the necessary e-beam dosage, would be harmless and inexpensive. Such a compound could greatly reduce the costs of electron beam disinfection of water.

The researchers assessed the use of Vitamin K, tertiary hydrobutylquinone,

lactic acid, acetic acid, and hydrogen peroxide. The first three compounds proved ineffective in reducing the necessary e-beam dose to inactivate *Cryptosporidium* in water. However, in research reported in 1998 the researchers found that by adding acetic acid to the water the e-beam dose necessary to achieve 100 % kill of *Cryptosporidium* was lowered by 25 percent.

In 1999, researchers repeated the success with acetic acid by demonstrating the effectiveness of hydrogen peroxide as a radiosensitizer. In this case, researchers reduced the e-beam dose necessary to achieve similar levels of inactivation of *Cryptosporidium* by 60 to 75 percent by the addition of hydrogen peroxide to the treated water. For instance, the project team lowered the e-beam dose needed to achieve a *Cryptosporidium* inactivation level of 40 percent from 250 krad to approximately 100 krad by adding hydrogen peroxide.

Unfortunately, high doses of hydrogen peroxide and acetic acid were needed to reduce the electron beam dose. The necessary acetic acid dose was more than 100 mg/L and the hydrogen peroxide dose was nearly 3,000 mg/L. There remains a question as to how much of an effect the high chemical dosages have on *Cryptosporidium* inactivation and how much is the result of a synergistic effect between the radiosensitizers and the electron beam irradiation.

At such high dosages, it is unlikely that this treatment scheme will find an application in most conventional water and wastewater treatment plants. Dosages must be lowered before it can become an economically viable water treatment alternative. The final project report will be available sometime in year 2000.